Q1) Part A

(a) velocity profile in laminar flow:-

As we have

$$h_L = \frac{\tau . 2L}{\xi r}$$

from viscosity $\Rightarrow \tau = \mu \frac{du}{dy}$ — (x)

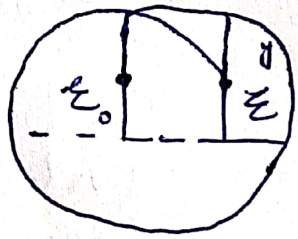
where "u" is velocity at distance "y" from the boundary.

Thus,

$$y = \xi_0 - \xi$$

$$dy = \cancel{d\xi_0} - d\xi$$

$$dy = -d\xi$$



$\because d\xi_0$ = constant value

Putting value in eq (x)

$$\tau = -\mu \frac{du}{d\xi}$$

Now, $h_L = \frac{\tau . 2 . L}{\xi r} . \xi dr$.

Integrating on both sides

$$\int du = \int -\frac{h\,G\,r}{2\mu l} \cdot \varepsilon \cdot d\varepsilon$$

$$u = -\frac{h\,G\,r}{2\mu l} \cdot \frac{\varepsilon^2}{2} + C$$

Now for $\varepsilon = 0$, $u = u_{max}$

Putting value

$$u = \frac{-h\,G\,r}{2\mu l} \cdot \frac{\varepsilon^2}{2} + C$$

$u = U_{max}$, $U_{max} = 0 + C$

$C = U_{max}$

Thus $U = U_{max} - \frac{h\,G\,r}{2\mu l} \cdot \frac{\varepsilon^2}{2}$

(velocity at any point)

Assume $k = \frac{h\,G \cdot r}{4\mu l}$ $\therefore u = U_{max} - k\varepsilon^2$

As for $\varepsilon = \varepsilon_0$, $u = 0$

$0 = U_{max} - k\varepsilon_0^2$ or

$U_{max} = k\varepsilon_0^2 = \frac{h\,G\,r}{4\mu l} \cdot \varepsilon_0^2$

It is also known as critical velocity.

Now,

$$V_{av} = \frac{V_{CE} + 0}{2} = 0.5\ V_{CE}$$

↑

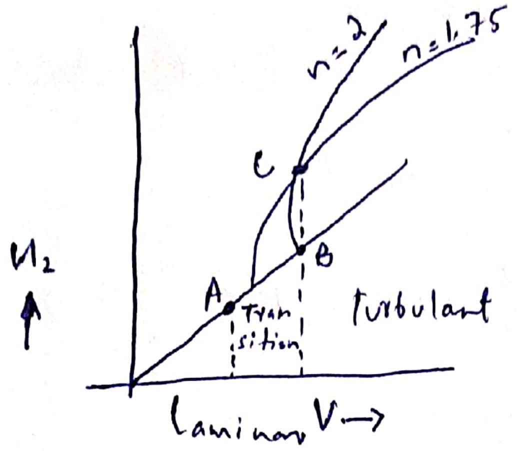
average velocity

Q1) Part B :-

Ans) Critical Reynold number :-

If head loss in given length of uniform pipe is measured at different values of velocity. It will found that as long as velocity is low enough to secure laminar flow, the head loss due to friction will be directly proportional to velocity. but increase in velocity change flow from laminar to turbolant cause change in head loss thus if values are plotted, lines obtained with slope ranging about 1.75 to 2.

Thus for laminar, drop of energy varies as V and for turbulant, friction varies as V^n where n is 1.75 to 2.



The upper critical reynold number corresponding to point B is indeterminate and depend upon care taken to Prevent initial disturbance. Its value is 4000, but normally its impossible for flow to be in straight line after R is at 2000. Thus lower value is much more definite then higher one and is dividing point. Thus lower value is true critical Reynold number.

4) Equation:-

$$R = \frac{F_i}{F_v}$$, As we know

$F_i = ma$

$= (\rho . L^3) . (L/T^2)$

$= \rho . \frac{L^4}{T^4} \Rightarrow \rho (L/T)(L/T) . L^2 = \rho v^2 . L^2$

Now $F_v = \mu (du/dy) A$

$= \mu . \frac{v}{\cancel{L}} . \cancel{L^2} = \mu v L$

Now $R = \frac{L^2 v^2 \rho}{L v \mu} = \frac{L v \rho}{\mu}$ $\because (\mu / \rho = \nu)$

$\nu = \frac{\mu}{\rho}$ (kinematic viscosity)

$R = \frac{L v}{\nu}$, $R = \frac{D v}{\nu}$ (for circular pipe)

*) lower value 2000 is critical Reynold number

Q2)

*) GIVEN DATA :-

oil having $S = 0.7$

kinematic viscocity $= 1.8 \times 10^{-5}\ m^2/sec$

Dia of pipe $= 150mm = 0.15m$

flow $= 0.5\ l/sec = 0.0005\ m^3/sec$

*) Required data :-

centerline velocity = ?

velocity at 10mm from edge = ?

velocity at edge of pipe = ?

Max shear stress at wall = ?

*) Solution :-

first we check flow is laminar or turbulant.

$$R = \frac{Dv}{\nu} \quad \longrightarrow (i)$$

$$V = \frac{Q}{A} \Rightarrow \frac{Q}{\frac{\pi}{4}d^2} \Rightarrow \frac{0.0005}{\frac{\pi}{4}(0.15)^2} \Rightarrow V = 0.028 m/sec$$

$$R = \frac{(0.15)(0.028)}{1.8 \times 10^{-5}}$$

$$R = \underline{233.37} < 2000 \quad (\text{laminar})$$

$$V_{cr} = 2V \Rightarrow 2 \times 0.028$$

$$V_{cr} = \underline{0.056 \text{ m/sec}}$$

As;

$$u = u_{max} - kr^2$$

at

$$r = r_0 \Rightarrow 0.075\text{m}, \quad u = 0$$

Thus

$$\cancel{u}^{0} = u_{max} - kr^2$$

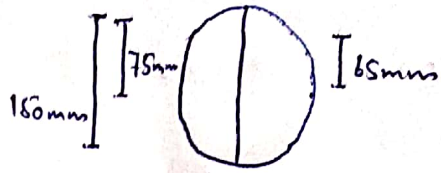
$$u_{max} = kr^2$$

$$k = \frac{u_{max}}{r^2} = \frac{0.056}{(0.075)^2}$$

$$\underline{k = 9.96}$$

we get a equation;

$$u = 0.056 - 9.96(r^2) \quad \text{--- (ii)}$$



*) velocity at 10mm from edge:-

$r = 0.065m$

$V = (0.065)^2\, 9.96 - 0.056$

$V = 0.014\ m/sec$

*) Velocity at edge;-

$r = 0.075m$

$V = 0.056 - 9.96\,(0.075)$

$V = -0.00002\ m/sec$ say,

$V = 0$

Similarly;

$$f = \frac{64}{R} = \frac{64}{233.33}$$

$f = 0.27$

Scanned with CamScanner

4) Shear stress at wall :-

$$\tau = \frac{f}{4} \rho \frac{V^2}{2}$$

$$= \frac{0.27}{4} \times (0.7 \times 1000) \times \frac{(0.056)^2}{2}$$

$$\underline{\tau = 0.074 \ N/m^2}$$

Answer.